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The Effects Of Short-Term Fasting On Fat Utilization During Jogging

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THE EFFECTS OF SHORT-TERM FASTING ON FAT UTILIZATION DURING JOGGING

SMITH

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The Effects of Short-Term Fasting on

Fat Utilization During Jogging

(TITLE)

BY

Dianne M. Smith

THESIS

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Abstract

THE EFFECTS OF SHORT-TERM FASTING ON
FAT UTILIZATION DURING JOGGING

Dianne M. Smith

This study was designed to examine the effects of short-term fasting on fat utilization during jogging. Specifically, this study examined the effects of a 12 hour fast as compared to a 3 hour fast on fat utilization. Six males (mean age, 31 yrs; weight, 76.9 kg; body fat, 15.3 percent; max VO_2, 57.3 ml/kg/min) and six females (mean age, 30 yrs; weight, 58.6 kg; body fat, 21.4 percent; max VO_2, 52.4 ml/kg/min) participated in this study. Each subject completed a maximum oxygen consumption test and two 30 minute runs at approximately 60 percent of their maximal aerobic capacity (max VO_2, ml/kg/min). The two submaximal runs were completed on separate days but at the same time of the day, seven days apart. Throughout the fasted runs, at five minute intervals beginning with minute five of each run, two minute respiratory gas analyses were performed. Information was collected and computed by an integrated Apple IIe microcomputer system. Mean and standard deviation values for oxygen consumption (L/min and ml/kg/min), percent max VO_2, pulmonary

ventilation (L/min), caloric expenditure (Kcals/30 min), heart rate (BPM and percent of max HR), rating of perceived exertion (RPE) and respiratory exchange ratios (R) were determined for each subject, based on the values recorded during the second minute of each gas sampling period. A two-way ANOVA ($p < .01$) was used to determine whether differences in fat utilization, based on the mean R value, existed between sexes and between the fasted runs. Fat oxidation was significantly enhanced by fasting 12 hours prior to a submaximal bout of jogging, but there was no significant difference in fat metabolism between males and females. Mean values for rating of perceived exertion (RPE), percent of max VO_2, pulmonary ventilation (V_E), oxygen consumption (VO_2) and respiratory exchange ratio (R) remained relatively consistent for the fasted runs. Mean heart rate was the only variable that did not attain a steady-state level for the fasted runs.

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CHAPTER 1

Introduction

In the United States today, one of the major health problems for millions of Americans, regardless of age, sex or race, is obesity. In fact, researchers have estimated that approximately 50 million men and 60 million women between the ages of 18 and 79 are "too fat" and need to reduce excess weight (Abraham and Johnson, 1980). Furthermore, statistics indicate that in developed countries, 35 percent of the adult population are obese and the prevalence of obesity is increasing (Craddock, 1978).

Scientific studies have identified three ways of promoting weight loss through the manipulation of diet and/or exercise. They are:

1. To reduce caloric intake below daily energy requirements, better known as dieting;

2. To maintain regular food intake and increase caloric output through additional physical activity or exercise; or,

3. To combine methods (1) and (2) by decreasing daily caloric intake and increasing daily energy expenditure (McArdle, Katch, and Katch, 1981).

Researchers have reviewed all three methods, finding that the combination of decreasing caloric intake and increasing caloric output through additional physical activity has been observed to be the optimal means of promoting fat weight loss while sparing lean body tissues (Zuti and Goldman, 1976; Weltman et al., 1980).

Moreover, researchers have identified that the mode of activity needed to enhance total body weight and fat weight loss is aerobic activity that requires large muscle activity, such as is used for walking or jogging. This activity needs to be performed a minimum of three days per week for at least 30 minutes per exercise session (Wilmore et al., 1970; Pollock et al., 1969). The intensity and duration must be sufficient to cause an energy expenditure of at least 300 kilocalories (kcals) per exercise session (Gwinup, 1975; Pollock, 1973). Fat weight loss can be further enhanced by increasing the frequency of exercise from three to five days per week and/or increasing the duration from 30 to 60 or more minutes per workout (Leon et al., 1979; Zuti and Golding, 1976).

The results of the various studies on diet and exercise have been statistically verified and a set of guidelines for proper weight reduction and loss of body

fat have been established and are supported by professional organizations such as the American College of Sports Medicine (ACSM, 1980).

Despite the findings of research and the establishment of guidelines for proper weight reduction, a large population of people throughout the United States, who are actively involved in exercise and/or weight loss programs, are still "overfat." There appears to be a need to determine whether there are other means of enhancing fat utilization during exercise.

Statement of the Problem

The purpose of this investigation was to examine the effects of short-term fasting on fat utilization during jogging. Specifically, this study examined the effects of a 12 hour fast as compared to a 3 hour fast on fat utilization.

Importance of the Study

The purpose of this study was to examine the effects of a 12 hour fast as compared to a 3 hour fast on fat utilization during jogging. Researchers have identified that steady-state, submaximal exercise performed at an appropriate intensity, duration and frequency and combined with caloric restriction can enhance the mobilization and utilization of fat, thus

increasing fat weight loss and at the same time, sparing the loss of fat-free tissue (McArdle, Katch and Katch, 1981; Zuti and Goldman, 1976; Pollock et al., 1969; Leon et al., 1979; Weltman et al., 1980).

Americans who are adhering to the guidelines established as a result of these studies should become less fat. However, statistics indicate that the American population is getting fatter every decade and thus, more and more people are becoming obese (Craddock, 1978). The question remains, is there another means of enhancing fat mobilization and utilization during exercise? The need for further fat utilization investigations is evident.

Various ergogenic aids such as caffeine, the time of day chosen to exercise and other dietary manipulations such as fasting for specified periods of time are thought to enhance fat utilization during exercise.

In one study, Havel et al., (1963) studied the effects of fasting 12 hours prior to performing sub-maximal, steady-state walks on a treadmill. Results indicate that fatty acids were the major fuel delivered to the working muscle from the blood in the post-absorptive state. More specifically, 41-49 percent of the total metabolism was represented by the oxidation of fatty acids.

A similar study by Osness et al., (1968) supported the findings of Havel and his associates.

Because few researchers have evaluated the effects of short-term fasting (i.e., less than 12 hours) on fat utilization, this study was begun.

Null Hypothesis

In this study, the null hypothesis was that no difference in fat utilization would be seen in joggers who had fasted for 12 hours as compared to 3 hours prior to performing a 30 minute, submaximal bout of jogging on a treadmill.

Limitations of the Study

This study was limited by several factors. Although subjects were instructed not to eat food or drink liquids other than water, smoke or vigorously exercise for specified periods of time prior to jogging on the treadmill, it was impossible to know whether they actually abstained for those specified periods of time. Secondly, the subjects were asked to maintain a consistent level of physical activity throughout the 21 days it took to complete the study, but it was difficult to verify their faithfulness. Thirdly, the composition of each subject's diet (percent carbohydrate, fats, and protein) 12-24 hours prior to the fasting periods was not restricted.

Delimitations of the Study

Subjects could not be older than 35 years of age and could not have any medical problems that would affect their ability to jog on a treadmill and/or alter the results of a maximal oxygen consumption test. Subjects also had to be actively engaged in a jogging program for at least two months prior to the testing periods and be able to sustain submaximal jogging for a period of 30 minutes on a treadmill.

Definition of Terms

The following terms have been defined for this study.

Caloric Expenditure

Caloric expenditure is the total number of kilocalories burned per unit of time.

Carbohydrates

Carbohydrates are organic compounds that serve as a main source of energy for all body functions and are necessary for the metabolism of other nutrients.

Fasting

Fasting is the act of abstaining from food and all liquid beverages except water for a required period of time.

Fats

Fats are biologically active substances that provide energy for the body.

Fat-free Weight

Fat-free weight is the component of an individual's total body weight (i.e., bones, muscles, tissues and body fluids) that is free of body fat.

Fatty Acids

Fatty acids are organic acids released from simple body fats, known as triglycerides. They provide energy for the body, especially during prolonged exercise.

Fat Weight

Fat weight is the portion of an individual's total body weight that is composed of body fat.

Kilocalorie (Kcal)

A kilocalorie is the amount of heat energy needed to raise the temperature of one kilogram of water one degree Centigrade.

Maximal Oxygen Consumption (VO_2 max)

Maximal oxygen consumption is the maximal amount of oxygen the body is capable of consuming per minute during vigorous exercise.

Obesity

Obesity is a condition whereby an individual has an excessive amount of body fat.

Protein

Protein is a food substance used primarily by the body to build and replace cells.

Respiratory Exchange Ratio (R)

Respiratory exchange ratio is the ratio of the volume of carbon dioxide expired in relation to the volume of oxygen consumed per minute (VCO_2/VO_2). It is used to identify the nutrient mixture or substrate being metabolized for energy by the body at rest and during submaximal exercise. It is usually referred to as the non-protein R.

Assumptions of the Study

The human body needs a source of energy in order to maintain itself as a living unit. The raw foodstuffs consumed by human organisms are classified into three primary categories: carbohydrates, fats and proteins. It is assumed that all three foodstuffs (alone or together) can be utilized to supply energy for the body but metabolic studies indicate that 98 percent of the energy is derived from carbohydrates and fats and only

two percent or less is supplied by proteins (Konopka et al., 1985). Researchers, therefore, indicate that it is not necessary to discuss protein as a contributor to the production of energy for the body (Osness et al., 1968; Konopka et al., 1985).

An average resultant of all metabolic events occurring in the body, independent of pathways, can be determined through the analysis of gaseous exchange occurring in the lungs (Fritz, 1961). A ratio is established for the volume of carbon dioxide expired in relation to the volume of oxygen consumed per minute (VCO_2/VO_2). This value is known as the non-protein respiratory exchange ratio (R). Corresponding values that indicate the percentage of fats and carbohydrates being metabolized have been established for each R value (Sinning, 1975). For example, a respiratory exchange ratio of 0.70 indicates 100 percent fat oxidation; 1.0 indicates 100 percent carbohydrate oxidation; and 0.85 indicates almost equal contributions from both substrates (i.e., a mixed diet). These non-protein R values were employed as guidelines during the analysis of R values for each fasted, submaximal run.

Lactate production during exercise is known to inhibit free fatty acid mobilization from adipose tissue (Issekutz et al., 1965). Various researchers have

found that exercise performed at an intensity of 70 percent or less of the max VO_2 results in little or no lactate production (Costill, 1970; Hermansen and Stensvold, 1972; Nagle et al., 1970; Powers et al., 1980). In order to minimize the possibility of lactic acid production, an exercise intensity of approximately 60 percent of VO_2 max was chosen for the exercise intensity for the fasted, submaximal runs in this study.

CHAPTER 2

Review of Related Literature

Very little current literature was found that related to the effects of short-term fasting (i.e., 12 hours or less) on the enhancement of fat utilization during jogging or other aerobic, large muscle activities. In fact, prior to the early 1940's, adipose tissue was thought to be "an inert, functionless storage of substances that could be mobilized for energy only when the food supply appeared inadequate and unable to keep up with the energy demands of the body" (Osness et al., 1968).

Researchers now know that adipose tissue is functionally very active and provides energy for living organisms at all times. Researchers have identified the main lipid substrate released from adipose tissue to the working muscle as the free fatty acid (Fredrickson and Gordon, 1958). More recent scientific studies indicate that fatty acids are the primary fuels used in oxidative metabolism during prolonged, steady-state work (Issekutz et al., 1966; Paul and Issekutz, 1967).

Havel et al., (1963) studied plasma fatty acid turnover in post-absorptive (i.e., 12 hour fasted)

and glucose fed varsity wrestlers during steady-state walking on a treadmill. By means of a continuous intravenous infusion of palmitate 1 C^{14}, he found that 57-87 percent of the fatty acids turned over from the plasma were readily oxidized by the subjects under both conditions. Thus, the utilization of available fatty acids did not appear to be altered by either condition.

Havel et al., (1963) did, however, find that mobilization of fatty acids from the adipose stores was decreased by the ingestion of glucose prior to a treadmill walk. Moreover, in the 12 hour fasted condition, 41-49 percent of the total metabolism was represented by readily oxidized fatty acids. In the glucose-loaded condition, the percentage of readily oxidized fatty acids dropped to 9-10 percent.

A later study by Osness et al., (1968) examined the metabolic activity of lipid substrates in six, 12 hour fasted male subjects at rest and while riding a bicycle ergometer at one-third and two-thirds of their maximal aerobic work capacity. Results of this study showed a twofold increase in the percentage of fatty acids utilized during both levels of exercise intensity as compared to the percentage of fatty acids utilized at rest. Specifically, this study reported that fatty

acid utilization increased from 25 percent at rest to 50 percent during both of the exercise workloads.

Another study, designed to investigate whether or not women could better utilize fat as a fuel for muscular exercise than men, assessed the fat utilization of men and women during a 90 minute treadmill run at about 65 percent max VO_2. All subjects had fasted 12 hours prior to the run. Results indicated that the percentage of energy metabolism dervied from fat oxidation increased from approximately 66 percent to 80 percent during the 90 minute, treadmill run (Powers et al., 1980).

These studies have indicated that fatty acids were the primary fuel substrate utilized in the 12 hour fasted subjects. Moreover, the percentage of fatty acids utilized during steady-state walking on a treadmill in a 12 hour fasted state was approximately four to five times greater than the percentage utilized by the glucose fed subjects (Havel et al., 1963).

Researchers in the previously mentioned studies were primarily interested in assessing the metabolic role of fatty acids during exercise. Currently, there appears to be some interest in promoting weight loss through the enhancement of fatty acid utilization during steady-state exercise.

During prolonged, steady-state exercise, research findings indicate that fatty acids are the primary fuels utilized (Issekutz et al., 1966 and Paul and Issekutz, 1967). Moreover, fatty acids may supply approximately 50 percent of the substrates utilized during the first hour of light and moderate steady-state exercise and their utilization may be more enhanced by exercising at light and moderate intensities for periods of time beyond one hour (McArdle, Katch and Katch, 1981).

Fat utilization was also enhanced when subjects in the Havel et al., (1963) and Osness et al., (1968) studies fasted for 12 hours prior to the steady-state bouts of aerobic exercise. The combination of the two conditions, fasting 12 hours prior to performing steady-state exercise at an intensity of 66 percent or less of maximal aerobic capacity, may serve to describe a more optimal way of enhancing fat utilization and thus, reducing body fat through exercise.

A recently published study by Wilcox et al., (1985) assessed the effects of fasting for specific periods of time, 12 and 3 hours, respectively at two different times of the day, morning and early afternoon. Fat utilization was more enhanced during the morning run after a 12 hour fast than it was during the afternoon run after a 3 hour fast. Wilcox concluded that

a pound of fat will be oxidized sooner when exercising in the morning after a 12 hour fast than when doing the same exercise 3 hours after the last meal. Wilcox's study did not assess whether the enhancement of fat utilization during the morning runs was due to the fasted condition, the time of day or both.

Therefore, the lack of current literature to support the findings of Havel et al., (1963) and Osness et al., (1968) and the need to further evaluate whether the findings of Wilcox et al., (1985) were due to the 12 hour fast or the time of day chosen to exercise, indicates a strong need to further investigate the effects of short-term fasting (i.e., not exceeding 12 hours) on the enhancement of fat utilization during submaximal aerobic exercise.

CHAPTER 3

Methodology

The purpose of this study was to examine the effects of a 12 hour fast as compared to a 3 hour fast on fat utilization during submaximal jogging. This chapter describes the subjects, testing procedures and the methods used in the study.

Subjects

Six female and six male adults, ranging in age from 26 to 35 years, volunteered to participate in this study. The males are described in Table 1 and the females in Table 2. Each read and signed an informed consent document (Appendix A) and all were currently involved in a jogging program for at least two months prior to the completion of a resting evaluation.

Testing Procedures

All testing procedures were conducted in the Human Performance Laboratory at Eastern Illinois University. Each subject completed a resting evaluation prior to being accepted as a subject for this study. Each subject then completed a maximal oxygen consumption test and two 30 minute submaximal runs at approximately 60 percent max VO_2. Each treadmill

Table 1

General Descriptive Data
For Males

Resting Values

Subject	Age yrs	Height cm	Weight kg	Body Fat %	Heart Rate BPM	Blood Pressure mmHg
1	26	179.1	84.0	16.1	56	124/86
2	32	188.0	86.0	19.5	72	134/86
3	35	184.2	80.2	19.1	66	128/82
4	30	172.7	56.8	7.9	66	122/80
5	30	177.8	67.5	10.1	62	108/70
6	33	182.9	86.6	18.9	68	136/84
Mean	31	180.8	76.9	15.3	65	125/81
S.D.	3.1	5.4	12.1	5.1	5.5	10/6

Table 2

General Descriptive Data
For Females

Resting Values

Subject	Age yrs	Height cm	Weight kg	Body Fat %	Heart Rate BPM	Blood Pressure mmHg
1	24	160.0	64.5	26.7	64	118/86
2	28	162.6	51.7	19.5	72	114/76
3	35	171.5	64.0	23.6	64	108/70
4	26	157.5	48.0	16.9	62	104/68
5	34	170.2	72.0	21.5	62	100/64
6	31	147.3	51.5	20.1	46	90/58
Mean	30	161.5	58.6	21.4	59	106/70
S.D.	4.4	8.6	9.5	3.4	10.2	10/10

run was completed on separate days but on the same day of the week at approximately the same time of day, seven days apart.

Preliminary Screening of Subjects

One week prior to the scheduling of the first testing session, each prospective subject individually reported to the EIU Human Performance Laboratory. Each subject read a written informed consent document and was given a verbal explanation of the purposes, benefits and risks of the resting evaluation, the max VO_2 test, and the two submaximal treadmill runs. A note describing the fasting procedures was also included.

Each subject signed the informed consent document, completed a health history questionnaire and a resting evaluation. Resting measurements taken were: a resting 12-lead electrocardiogram (ECG), blood pressure, heart rate, weight, height, vital capacity, forced vital capacity and skinfold measurements (for determining body density). The Jackson-Pollock body density estimation formula (1985) was used to determine each subject's body density. Percent body fat was then calculated from body density, using the Siri equation (Siri, 1961).

Each subject was orientated and practiced walking on the treadmill. A brief explanation of the maximal

oxygen consumption test was given and subjects were instructed to abstain from smoking, eating and consumption of liquids other than water for two hours prior to the test, and to abstain from vigorous exercise for 24 hours prior to the test.

Each subject also selected a day (Saturday or Sunday) and time for completing each of the treadmill runs. The order of tests for each subject was randomly determined.

Subjects were required to maintain, in duplicate, a dietary log of all foods and beverages consumed 24 hours prior to the maximal oxygen consumption test. One copy of the dietary log was given to the investigator on the day of the max VO_2 test.

The Equipment and Its Preparation

A computer-controlled Quinton Q65 treadmill with a Q2000 stress test monitor attached was used for the max VO_2 tests. An A. R. Young treadmill was used for the 30 minute submaximal runs. Both treadmills were calibrated prior to the beginning of this study.

An open circuit oxygen consumption system, consisting of a Jack Daniels low-resistance respiratory valve, an Applied Electrochemistry Model S-3A oxygen analyzer

and a Model CD-3A carbon dioxide analyzer integrated with an Apple IIe microcomputer with software was utilized to collect and analyze the expired air. The gas analyzers were calibrated before each treadmill run with room air and reference gases of known concentrations. A Rayfield RAM 9200 gas meter integrated with an Apple IIe system measured inspired air volumes for the determination of pulmonary ventilation (V_E) in liters per minute.

Oxygen consumption (VO_2, L/min and ml/kg/min), carbon dioxide production (VCO_2, L/min) and respiratory exchange ratio (R) values were recorded and saved on the computer every 30 seconds during the max VO_2 test. Throughout the 30 minute runs, at five minute intervals beginning with minute five of each run, two minute respiratory gas analyses were performed.

Oxygen consumption and pulmonary ventilation values were corrected to Standard Temperature and Pressure-Dry (STPD). Ambient temperature (degrees Centigrade), barometric pressure (mmHg) and humidity (percent) were recorded prior to each treadmill run. Ambient temperature varied on a daily basis from 22-24 degrees Centigrade; relative humidity, 29-40 percent; and barometric pressure, 736-756 mmHg.

Maximal Oxygen Consumption Test

Each subject completed a graded exercise test (GXT) 24-hour history questionnaire (Appendix B), signed an informed consent for GXT letter (Appendix C) and was prepped for a five-lead exercise electrocardiogram. The maximal oxygen consumption test and use of Borg's Rating of Perceived Exertion Scale (RPE) were explained prior to the beginning of the test.

An individualized jogging protocol was designed for each subject, based on his/her present level of weekly jogging and mile per hour pace. Each subject was provided a five minute warmup (two minutes of walking and three minutes of jogging) on the treadmill prior to the beginning of the test protocol. Speed and/or percent grade were increased every two minutes until the subject indicated a need to terminate the test or an event occurred (as specified by the American College of Sports Medicine) that indicated the test should be stopped (ACSM, 1980).

Electrocardiogram leads II, V_2 and V_5 were monitored at rest, during the test and throughout the recovery period. Pre-exercise heart rates and blood pressures were recorded at rest in a sitting position. During the test, heart rate was recorded every minute

while rating of perceived exertion (RPE) values were recorded at the conclusion of each exercise stage. Blood pressure was taken at the conclusion of the test, the last 15 seconds of each minute of recovery and in a seated position at the conclusion of the recovery period.

The recovery period consisted of a slow walk on the treadmill for a minimum of five minutes, longer if needed. An ECG tracing was recorded at the moment the test was terminated in order to verify the maximal heart rate achieved by each subject.

Values for oxygen consumption (VO_2, L/min and ml/kg/min), pulmonary ventilation (V_E, L/min), carbon dioxide production (VCO_2, L/min) and respiratory exchange ratio (R) were collected, calculated and recorded every 30 seconds throughout the test with the aid of an on-line Apple IIe microcomputer system.

Submaximal Treadmill Runs

After a maximal oxygen consumption value (VO_2 max, ml/kg/min) was determined for each subject, he/she then completed two 30 minute runs at approximately 60 percent of their maximal aerobic capacity. Each run was completed at the same time of the day on the same day of the week,

seven days apart. One run was performed after a 12 hour fast; the other run, after a 3 hour fast. Subjects were requested to abstain from all foods and beverages containing caffeine, all alcoholic beverages and vigorous exercise during the 12 hour fasting period. Water consumption was not restricted.

Foods and beverages consumed 12-24 hours prior to the max VO_2 test were again eaten 12-24 hours prior to each fasted run. The last meal eaten three to three and one-half hours prior to the three hour fasted run consisted of two ounces of precooked dry cereal, one cup of two percent milk and water.

Upon arrival at the laboratory for each 30 minute run, each subject completed a 24-Hour History questionnaire. An AMF Quantum XL Fitness Monitor (heart rate monitor) was attached to each subject and a seated blood pressure, heart rate and body weight (kg) were recorded prior to each run. Exercise heart rates and rating of perceived exertion values were recorded every five minutes throughout the run.

Gas samples were collected and analyzed over a two minute period at five minute intervals throughout the run, with the first collection starting at minute five. Pulmonary ventilation (V_E, L/min) and respiratory exchange ratio (R) information was collected, calculated,

analyzed and recorded during the same time intervals. Values were computed and saved with an Apple IIe microcomputer system.

Statistical Procedures

Mean and standard deviation values for age, height, weight and percent body fat were calculated separately for females and males.

Maximal oxygen consumption (max VO_2, ml/kg/min) was determined for each subject based on the highest oxygen consumption level attained during the maximal oxygen consumption test. Maximal heart rate (max HR), rating of perceived exertion (RPE), respiratory exchange ratio (R) and pulmonary ventilation (V_E, L/min) were recorded immediately upon termination of the max VO_2 test. Mean and standard deviation values for max VO_2, RPE, V_E, max HR and R were calculated separately for females and males.

For the two, 30 minute fasted runs, mean values for oxygen consumption (VO_2, L/min and ml/kg/min), pulmonary ventilation (V_E, L/min), respiratory exchange ratio (R), heart rate (BPM), rating of perceived exertion (RPE), and percent of maximal heart rate were determined for each subject, based on the data recorded during the second minute of each gas sampling period.

A mean and standard deviation were computed for the intensity (percent max VO_2) of the fasted runs.

A table of standardized Non-protein Respiratory Quotients (Appendix D) was used to assess the mean percentage of fats and carbohydrates utilized and the caloric expenditure (Kcals/30 minutes) of each fasted run, based on the mean R value (Sinning, 1975).

A two-way analysis of variance with repeated measures ($p < .01$) was used to determine if differences in fat utilization, based on the mean R value, existed between sexes and between the fasted runs. In addition, the differences for rating of perceived exertion (RPE), heart rate (BPM), percent of maximal heart rate and percentage of max VO_2 between sexes and between the fasted runs were studied.

Statistical computations were calculated with a Sharp EL-506P hand-held calculator.

CHAPTER 4

Analysis of the Data

The purpose of this study was to examine the effects of a 12 hour fast as compared to a 3 hour fast on fat utilization during submaximal jogging. Six female and six male adults volunteered, were interviewed, physically evaluated and accepted as subjects.

Each subject completed a maximal oxygen consumption test, administered according to the American College of Sports Medicine guidelines for graded exercise testing. The results of the test were used to determine the maximal aerobic capacity (VO_2 max, ml/kg/min) of each subject (ACSM, 1980).

Each subject then completed two 30 minute runs on a treadmill at approximately 60 percent of their measured maximal aerobic capacity. Each 30 minute run was completed after a specified time period of fasting, 12 hours or 3 hours, respectively. Data recorded during the second minute of each gas sampling period throughout the runs was analyzed for this study.

A two-way analysis of variance (ANOVA) with repeated measures was used to determine if differences in fat utilization, based on the mean R value, existed

between sexes and between the fasted runs. Mean values for rating of perceived exertion (RPE), heart rate (BPM), percent of maximal heart rate, oxygen consumption (VO_2, L/min and ml/kg/min), pulmonary ventilation (V_E, L/min), percentage of max VO_2 and caloric expenditure (Kcals/30 minutes) were calculated for males, females and the entire sample for each fasted run. Mean values for each variable were reviewed in order to establish whether steady-state values were attained during the runs. Mean values attained for each fasted run were also compared. A presentation of the findings and a discussion of the data have been included in this chapter.

Presentation of the Findings

Maximal Oxygen Consumption Test

The endpoint for termination of all maximal oxygen consumption tests was subject fatigue. The mean maximal values attained were:

	max VO_2 ml/kg/min	max HR BPM	V_E L/min	R	RPE
males	57.28	194	112.97	1.13	18
females	52.41	184	84.14	1.06	18

Maximal values recorded for the males are presented in Table 3 and for the females, Table 4. Mean and standard deviation values, calculated independently for males and females, are included.

Submaximal Treadmill Runs

Each subject completed two 30 minute fasted runs at approximately 60 percent of their maximal aerobic capacity. Data recorded for each subject during the second minute of each sampling period of both runs was analyzed for this study and is included in Appendices E through P. Mean and standard deviation values were then calculated for males, females and the entire sample.

Mean and standard deviation values for the males are presented in Table 5. The 12 hour fasted run was performed at a mean intensity of 57.33 percent of max VO_2. Mean values calculated for the other measured variables were: 32.875 ml/kg/min and 2.492 L/min for VO_2; 143 BPM for heart rate; 72.8 percent of max heart rate; 49.378 L/min for V_E; 0.89 for R; 11 for RPE; and 365.73 Kcals for total caloric expenditure.

The 3 hour fasted run was performed at a mean intensity of 57.92 percent of max VO_2. Mean values calculated for the other measured variables were: 33.192 ml/kg/min and 2.515 L/min for VO_2; 143 BPM for

Table 3

Results of Maximal Oxygen Consumption Test for Males

Subject	RPE	VO_2 ml/kg/min	R	V_E L/min	HR BPM
1	19	57.73	1.13	118.87	198
2	17	49.30	1.11	105.86	204
3	15	52.24	1.12	120.59	197
4	20	68.66	1.13	94.75	190
5	18	53.23	1.11	120.74	188
6	20	62.51	1.16	117.00	188
Mean	18	57.28	1.13	112.97	194
S.D.	2	7.25	0.02	10.51	7

Table 4

Results of Maximal Oxygen Consumption Test for Females

Subject	RPE	VO_2 ml/kg/min	R	V_E L/min	HR BPM
1	18	47.90	1.10	97.03	184
2	19	55.51	1.01	69.03	190
3	20	45.78	1.11	83.78	188
4	18	58.83	1.05	83.68	188
5	17	53.75	1.00	97.43	174
6	18	52.70	1.06	73.87	178
Mean	18	52.41	1.06	84.14	184
S.D.	1	4.84	0.05	10.62	6

Table 5

Fasted Runs
Means and Standard
Deviations for Males

Variable	12 Hr. Fast M	12 Hr. Fast SD	3 Hr. Fast M	3 Hr. Fast SD
R	0.89	0.03	0.91	0.03
VO_2 (L/min)	2.49	0.24	2.52	0.31
RPE	11.00	1.00	11.00	1.00
% max HR	72.80	5.60	72.80	7.60
VO_2 (ml/kg/min)	32.88	4.80	33.19	5.13
% max VO_2	57.33	3.50	57.92	5.41
V_E (L/min)	49.38	6.15	50.63	7.59
HR (BPM)	143.00	12.00	143.00	16.00
Kcals/30 min	365.73	36.68	370.79	46.34

heart rate; 72.8 percent of max heart rate; 50.625 L/min for V_E; 0.91 for R; 11 for RPE; and 370.79 Kcals for total caloric expenditure of the run.

Mean and standard deviation values for the females are presented in Table 6. The 12 hour fasted run was performed at a mean intensity of 60.667 percent of max VO_2. Mean values calculated for the other measured variables were: 31.863 ml/kg/min and 1.867 L/min for VO_2; 141 BPM for heart rate; 76.9 percent of max heart rate; 40.67 L/min for V_E; 0.85 for R; 10 for RPE; and 270.742 Kcals for total caloric expenditure of the run.

The 3 hour fasted run was performed at a mean intensity of 58.333 percent of max VO_2. Mean values calculated for the other variables measured were: 30.662 ml/kg/min and 1.792 L/min for VO_2; 132 BPM for heart rate; 71.80 percent of max heart rate; 40.657 L/min for V_E; 0.89 for R; 11 for RPE; and 262.83 Kcals for total caloric expenditure of the run.

Mean and standard deviation values for the entire sample are presented in Table 7. The 12 hour fasted run was performed at a mean intensity of 59 percent of max VO_2. Mean values calculated for the other variables recorded during the run were: 32.369 ml/kg/min and 2.180 L/min for VO_2; 142 BPM for heart rate; 75 percent of max heart rate; 45.024 L/min for V_E; 0.87 for R;

Table 6

Fasted Runs
Means and Standard
Deviations for Females

Variable	12 Hr. Fast M	12 Hr. Fast SD	3 Hr. Fast M	3 Hr. Fast SD
R	0.85	0.03	0.89	0.02
VO_2 (L/min)	1.87	0.42	1.79	0.42
RPE	10.00	1.00	11.00	1.00
% max HR	76.90	4.40	71.80	3.30
VO_2 (ml/kg/min)	31.86	4.22	30.66	3.65
% max VO_2	60.67	3.88	58.33	4.37
V_E (L/min)	40.67	10.98	40.66	9.49
HR (BPM)	141.00	7.00	132.00	8.00
Kcals/30 min	270.74	61.86	262.83	60.47

Table 7

Fasted Runs
Means and Standard Deviations
of the Entire Sample

Variable	12 Hr. Fast M	12 Hr. Fast SD	3 Hr. Fast M	3 Hr. Fast SD
R	0.87	0.04	0.90	0.03
VO_2 (L/min)	2.18	0.44	2.15	0.51
RPE	11.00	1.00	11.00	1.00
% max HR	75.00	5.20	72.20	5.40
VO_2 (ml/kg/min)	32.37	0.72	31.93	1.79
% max VO_2	59.00	2.36	58.13	0.29
V_E (L/min)	45.02	6.16	45.64	7.05
HR (BPM)	142.00	1.00	138.00	8.00
Kcals/30 min	318.24	67.17	316.81	76.34

11 for RPE; and 318.236 Kcals for total caloric expenditure of the run.

The three hour fasted run was performed at a mean intensity of 58.125 percent of max VO_2. Mean values for the other variables were: 31.927 ml/kg/min and 2.154 L/min for VO_2; 138 BPM for heart rate; 72.2 percent of max heart rate; 45.641 L/min for V_E; 0.90 for R; 11 for RPE; and 316.81 Kcals for total caloric expenditure of the run.

Based on the mean R values calculated for the males, females and the entire sample, a corresponding percentage value for the percent of fats utilized for energy during each run was derived from the Non-Protein Respiratory Quotients table in Appendix D. The mean percentage of fats oxidized during each run is shown below.

	12 HR Fasted Run		3 HR Fasted Run	
	R	% Fats	R	% Fats
Males	0.89	36.7	0.91	30.0
Females	0.85	50.0	0.89	36.7
Group	0.87	43.3	0.90	33.3

Table 8 presents the analysis of variance (ANOVA) summary table. The two-way ANOVA indicated that fat utilization, based on the mean R, was significantly greater ($p < .01$) during the 12 hour fasted run as

Table 8

ANOVA Summary Table

Source of Variation	Degrees of Freedom	Sum of Squares	Variance	F
Fasting condition	1	.0048	.0048	12.6316[a]
Gender	1	.0048	.0048	4.0000
Fasting x Gender	1	.0011	.0011	2.8947
Within Subjects Error	10	.0038	.0038	
Between Subjects Error	10	.0120	.0012	
Total	23	.0265		

[a]Significant at the .01 level of confidence

compared to the 3 hour fasted run. The ANOVA also indicated that no significant difference in fat utilization ($p < .01$) existed between males and females during the runs.

Discussion of the Findings

In the present study, fat utilization was significantly more enhanced during submaximal jogging when preceded by a 12 hour fast. The percentage of fats oxidized during the 12 hour fasted run was 43.3 percent while the percentage of fats oxidized during the 3 hour fasted run was 33.3 percent, a difference of 10 percent. These findings are similar to the data reported by Havel et al., (1963), Osness et al., (1968) and Powers et al., (1980). Thus, the results of this study and the others listed above, indicate that fasting 12 hours prior to a submaximal run may increase the percentage of energy derived from free fatty acid metabolism, but not the total amount of kilocalories expended during the workout.

The two-way ANOVA also indicated that there was not a significant difference in fat utilization between males and females in this study. Similar results were concluded in a study by Powers et al., (1980). It appears that the percentage of fats utilized by

moderately trained men and women during submaximal work is not significantly different.

The time of day at which an individual performs a fasted run has been shown to affect the percentage of fats utilized during a submaximal run (Wilcox et al., 1985). The time of day at which each subject performed each of the two fasted runs during this study remained constant. Therefore, the increased utilization of fats during the 12 hour fasted run, as compared to the 3 hour fasted run, was due to the fasted condition of the subjects and not the time of day at which the runs were performed.

Lactic acid is known to inhibit the release of free fatty acids from adipose tissue (Issekutz et al., 1965). Various studies, however, have shown that exercise performed at an intensity of less than 70 percent of max VO_2 causes little or no lactate production (Costill, 1970; Hermansen and Stensvold, 1972; Nagle et al., 1970; and Power et al., 1980). Therefore, the intensity of the fasted, submaximal runs was set at approximately 60 percent of max VO_2 in order to minimize the production of lactic acid. The actual mean intensity of the runs was 58.56 percent of max VO_2. Therefore, the production of lactic acid during the runs was assumed to have been minimal.

According to McArdle, Katch and Katch (1981), oxygen consumption (VO_2) and heart rate values during submaximal, slow jogging at a steady pace should rise rapidly during the first few minutes of exercise and then, plateau (i.e., reach a steady-state) by the fourth minute and remain stable for the rest of the exercise period.

Steady-state oxygen consumption values were attained in this study. Values observed for the variables of perceived exertion, pulmonary ventilation, respiratory exchange ratio, caloric expenditure and percentage of max VO_2 were also consistent during each sampling period throughout both of the 30 minute runs for males and females. The only variable that did not remain consistent throughout the runs was heart rate. That is, the heart rate in most of the runs progressively increased.

In summary, the 12 hour fast, as compared to the 3 hour fast, significantly enhanced the percentage of fats utilized during the submaximal jogging activity, and fat utilization was not found to be significantly different for males and females.

The time of day at which each fasted run was completed remained constant. Therefore, the increased utilization of fats during the 12 hour fasted run as

compared to the 3 hour fasted run was due to the fasted condition and not the time of day at which the runs were performed.

CHAPTER 5

Summary, Conclusions, and Recommendations

This study was designed to examine the effects of short-term fasting on fat utilization during submaximal jogging. Specifically, this study examined the effects of a 12 hour fast as compared to a 3 hour fast on fat utilization.

Six males (mean age, 31 yrs; weight, 76.9 kg; body fat, 15.3 percent; max VO_2, 57.3 ml/kg/min) and six females (mean age, 30 yrs; weight, 58.6 kg; body fat, 21.4 percent; max VO_2, 52.4 ml/kg/min) participated in this study. Each subject completed a maximum oxygen consumption test and two 30 minute runs at approximately 60 percent of their maximal aerobic capacity (max VO_2, ml/kg/min). The two submaximal runs were completed on separate days but at the same time of the day, seven days apart.

Throughout the fasted runs, at five minute intervals beginning with minute five of each run, two minute respiratory gas analyses were performed. Information was collected and computed by an integrated Apple IIe microcomputer system. Mean and standard deviation values for oxygen consumption (L/min and ml/kg/min),

percent max VO_2, pulmonary ventilation (L/min), caloric expenditure (Kcals/30 min), heart rate (BPM and percent of max HR), rating of perceived exertion (RPE) and respiratory exchange ratios (R) were determined for each subject, based on the values recorded during the second minute of each gas sampling period.

A two-way ANOVA ($p < .01$) was used to determine if differences in fat utilization, based on the mean R value, existed between sexes and between the fasted runs.

Conclusions

Fat oxidation was significantly enhanced by fasting 12 hours as compared to 3 hours prior to a submaximal bout of jogging, but there was no significant difference in fat metabolism between males and females. Mean values for rating of perceived exertion (RPE), percent of max VO_2, pulmonary ventilation (V_E), oxygen consumption (VO_2) and respiratory exchange ratio (R) remained relatively consistent for the fasted runs. Mean heart rate was the only variable that did not attain a steady-state level for the fasted runs.

Recommendations

Because relatively few studies that evaluated the effects of short-term fasting on fat utilization

have been conducted, similar studies with other groups such as sedentary and obese individuals are needed in order to describe the effects in other populations.

The length of the submaximal runs could be increased from 30 to 45 minutes, thus establishing whether fat utilization might be further increased over a longer period of time.

A better understanding of the metabolic events occurring within an individual may be attained if values were obtained for basal metabolic rate prior to the runs. Collection and analysis of respiratory gases while standing on the treadmill prior to the beginning of each run may also provide a more thorough evaluation of the R value prior to assessing the effects of the fasts.

APPENDICES

APPENDIX A

INFORMED CONSENT DOCUMENT

Title of the Study

The Effects of Fasting on Fat Utilization During Jogging.

Investigator: Dianne Smith

I,_____, voluntarily consent to participate in this study which is designed to investigate the effects of fasting on fat utilization during jogging.

A resting evaluation that consisted of a health history questionnaire and an oral interview, a resting 12-lead ECG, assessment of vital lung capacity volume, forced expiratory volume, heart rate, blood pressure, height, weight and skinfold measurements for determining percent body fat has been completed. I understand that my medical history will be reviewed to determine whether any condition is present that would indicate that I should not participate in this study.

I understand that participation in this study involves four (4) visits to the EIU Human Performance Laboratory (Lantz Building) for testing purposes. I also understand and will follow the dietary and exercise guidelines described within the following paragraphs.

APPENDIX A (continued)

THE TREADMILL TESTS AND GUIDELINES OF THE STUDY

General Guidelines

During the course of this study (Jan. 29 - March 10), I will maintain a normal diet and a regular schedule of exercise. I will not start a weight reduction program nor will I change my present level of physical activity. The only changes in dietary and exercise activities that should occur between now and the completion of this study are those described within the following paragraphs of this document.

Twenty-four (24) hours prior to each scheduled treadmill test, I will not participate in any vigorous physical exercise or athletic events and I shall keep a written record of all foods and beverages consumed (if possible, describe portion sizes of all foods and beverages consumed; see attached log sheet).

Twelve hours prior to each test, I will abstain from food and beverages containing caffeine and/or alcohol.

Test One - Assessment of Maximal Oxygen Consumption

Two hours prior to this test, abstain from all food and beverages except water. Arrive at the testing site

APPENDIX A (continued)

Stretching may be done in the area adjacent to the treadmill room and a five minute warm-up walk on the treadmill will be provided prior to the actual test. Please arrive promptly for your scheduled test time.

This test will involve walking or jogging on a motor-driven treadmill while breathing room air through a respiratory mouthpiece. The test will start with a five (5) minute warm-up walk or jog with no incline and will gradually increase in speed and incline every two minutes until the effort causes fatigue. The subject will indicate to the investigator when he/she wants the test terminated. The effort of this test is similar to the effort of competing in a half-mile race. Heart rate, blood pressure and ECG will be monitored during the test and throughout the recovery period (a minimum of five (5) minutes).

Test Two and Test Three

These two runs will be completed on separate days at the same time of the day on the same day of the week. Each test will require the subject to "fast" for a specified period of time prior to jogging for 30 minutes on the treadmill at an intensity of 60 percent of the subject's measured maximal oxygen consumption. Oxygen consumption will be collected either continuously or periodically throughout the 30 minute runs, utilizing

APPENDIX A (continued)

the same procedures and equipment utilized for the maximal oxygen consumption test. Specific guidelines for "fasting" are described within this document and each subject will be scheduled for all three tests and verbally given the specific guidelines of the study and the "fasting" trials on the day you receive this document.

The Twelve-Hour "Fast"

As stated earlier, do not participate in any vigorous exercise or athletic competition 24 hours prior to this treadmill run. Twelve (12) to twenty-four (24) hours prior to the scheduled time of this treadmill run, consume the same foods and beverages that you consumed during this time period prior to your maximal oxygen consumption test (review your dietary log). Twelve hours prior to your scheduled test time, abstain from all foods and beverages except water. Arrive at the lab at your scheduled test time, stretch and procede to the treadmill for a five minute warm-up walk.

The Three-Hour "Fast"

The same guidelines as stated above are to be observed except that each subject will eat the following foods three hours prior to this 30 minute treadmill run.

APPENDIX A (continued)

Two ounces of precooked dry breakfast cereal of your choice (measure a two ounce serving according to the quantity specified on the side of the box)
One cup of 2 percent milk
Water as needed

This meal should be consumed not earlier than three and one-half hours prior to the scheduled test time.

I understand that the maximal oxygen uptake test will produce feelings of fatigue that may take several minutes to subside. There exists a possibility of certain changes occurring during the tests. They include abnormal blood pressure, fainting, disorders of heart beat, muscle soreness and/or stiffness and in very rare instances, heart attack. I understand that every effort will be made to minimize problems by preliminary examination and by observation during the testing. I also understand that trained personnel will be available to deal with unusual situations which may arise.

The benefits of participation in this study include the acquisition of knowledge concerning my physical condition, my heart and circulation and an accurate determination of my aerobic capacity. I will also be participating in a scientific research project that will contribute to our understanding of the effect of fasting

APPENDIX A (continued)

on fat utilization during exercise. The results may help to describe the optimal conditions under which fat may be reduced through exercise.

I understand that the data derived from my participation in this project will remain confidential. I will be informed of the results of my tests, but I will not be identified in any way in any subsequent presentation or publication of the results of this study.

I understand that the investigator will answer any questions I may have concerning the procedures or the purpose of the study. I also understand that I may withdraw my consent and discontinue my participation in the experiment at any time.

I understand that in the event of physical injury resulting from the research procedure involved in the experiment, no financial compensation will be available.

In signing below, I acknowledge that I have read and understand the procedures and potential risks of the study and that I voluntarily give my consent to participate in the above-described investigation.

Signature_____ Date_____

APPENDIX A (continued)

The test dates for this study are:

Sat., February 8 and Sun., February 9

Sat., February 22 and Sun., February 23

Sat., March 1 and Sun., March 2

My scheduled test dates and times are:

Test Name	Day	Date	Time
Max VO2	_____	Feb.	_____
12 HR Fast	_____	Feb.	_____
3 HR Fast	_____	March	_____

APPENDIX A (continued)

TWENTY-FOUR HOUR DIETARY LOG

List all foods and beverages consumed within the 24 hours preceding your first scheduled test time (the maximal oxygen consumption test). Place an asterick (*) beside the foods and the beverages you consumed 12-24 hours prior to your scheduled test time. You will consume these same foods and beverages and a similar amount (portion) of each, 12-24 hours prior to each of the other two treadmill runs. REMEMBER: Twelve (12) hours prior to all three tests, do not consume foods and beverages that contain caffeine and/or alcohol.

APPENDIX B

GXT 24-HOUR HISTORY FORM

Name: _____

Date: _____ Time: _____

How much sleep did you get last night?
(Please circle one)
1 2 3 4 5 6 7 8 9 10 (hours)

How much sleep do you normally get? (Please circle one)
1 2 3 4 5 6 7 8 9 10 (hours)

How long has it been since your last meal or snack?
(Please circle one)
1 2 3 4 5 6 7 8 9 10 11 12
(hours)

List the items eaten below:

_____

When did you last:
Have a cup of coffee or tea _____
Smoke a cigarette, cigar or pipe _____
Take drugs (including aspirin) _____
Drink alcohol _____
Give blood _____
Have an illness _____
Suffer from respiratory problems _____

What sort of physical exercise did you perform yesterday?

_____

What sort of physical exercise did you perform today?

_____

Describe your general feelings by checking one of the following:

_____ Excellent
_____ Very, Very Good
_____ Very Good
_____ Neither Bad nor Good
_____ Bad
_____ Very Bad
_____ Very, Very Bad
_____ Terrible

APPENDIX C

Informed Consent for Graded Exercise Testing

In order to determine accurately my level of physical fitness and capacity for exercise, I hereby consent to engage voluntarily in an exercise tolerance test to evaluate the condition of my heart and circulation. The information obtained in this test will be used to determine the workload I shall perform during a fat utilization study.

Before undergoing these tests, I understand my medical history will be reviewed to determine whether any condition is present which would indicate that I should not submit to these tests.

The tests which I will undergo will be performed on a treadmill with the amount of effort (speed and/or incline) increasing gradually. The increase in effort will continue until symptoms such as fatigue, shortness of breath, or chest discomfort appear; symptoms which would indicate that the test should be stopped. I recognize that I will stop the exercise at my discretion when I have reached a point where I no longer want to continue.

During the performance of the tests, a trained observer will keep me under close surveillance by monitoring my heart rate, blood pressure and electrocardiogram. My oxygen consumption will be measured.

There exists a possibility of certain changes occurring during the tests. They include abnormal blood pressure, fainting, disorders of heart beat, and very rare instances of heart attack. I understand that every effort will be made to minimize problems by preliminary examination and by observation during the testing. I also understand that trained personnel will be available to deal with unusual situations which may arise.

I have read the foregoing carefully and I understand its contents. Any questions which may have occurred to me concerning this informed consent have been answered to my satisfaction.

Date_____ Signature_____ Witness_____

APPENDIX D

CALORIC EQUIVALENTS FOR OXYGEN AT DIFFERENT NON-PROTEIN RESPIRATORY QUOTIENTS

Respiratory Quotient (R.Q.)	(kcal./liter)	Foodstuff Contributions	
		Fat (%)	*Carbohydrate* (%)
0.70	4.60	100.0	0.0
0.71	4.62	96.7	3.3
0.72	4.63	93.3	6.7
0.73	4.64	90.0	10.0
0.74	4.66	86.7	13.3
0.75	4.68	83.3	16.7
0.76	4.69	80.0	20.0
0.77	4.71	76.7	23.3
0.78	4.72	73.3	26.7
0.79	4.74	70.0	30.0
0.80	4.75	66.7	33.3
0.81	4.77	63.3	36.7
0.82	4.78	60.0	40.0
0.83	4.80	56.7	43.3
0.84	4.81	53.3	46.7
0.85	4.83	50.0	50.0
0.86	4.84	46.7	53.3
0.87	4.86	43.3	56.7
0.88	4.87	40.0	60.0
0.89	4.89	36.7	63.3
0.90	4.90	33.3	66.7
0.91	4.92	30.0	70.0
0.92	4.93	26.7	73.3
0.93	4.95	23.3	76.7
0.94	4.96	20.0	80.0
0.95	4.98	16.7	83.3
0.96	4.99	13.3	86.7
0.97	5.01	10.0	90.0
0.98	5.02	6.7	93.3
0.99	5.04	3.3	96.7
1.00	5.05	0.0	100.0

APPENDIX E

SUBJECT 1

12 HR Fasted Run AMB. TEMP. - 24 C HUMIDITY (%) - 38
WEIGHT - 85.5 KG BARO. PRES. - 744 MM HG
RESTING HR - 60 RESTING BP - 124/82
TREADMILL SPEED - 6.5 mph % max VO_2 - 56
CALORIC EXPENDITURE (Kcal/30 min) - 402.78

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	52.65	2.69	31.46	2.45	0.91	134	30	12
10	55.09	2.75	32.16	2.50	0.91	142	28	12
15	55.45	2.78	32.51	2.50	0.90	146	34	12
20	55.29	2.66	31.22	2.41	0.90	150	36	12
25	56.79	2.80	32.86	2.50	0.89	150	32	13
30	55.87	2.75	32.28	2.46	0.89	154	37	13
Mean	55.19	2.74	32.08	2.47	0.90	146	33	12

APPENDIX E (continued)

SUBJECT 1

3 HR Fasted Run (JB) AMB. TEMP. - 23 C HUMIDITY (%) - 39
WEIGHT - 84.8 KG BARO. PRES. - 736 MM HG
RESTING HR - 48 RESTING BP - 124/84
TREADMILL SPEED - 6.5 mph % max VO_2 - 57.5
CALORIC EXPENDITURE (Kcal/30 min) - 413.69

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15	54.92	2.75	32.42	2.48	0.90	143	23	11
20	54.84	2.83	33.37	2.51	0.89	148	33	11
25	56.23	2.86	33.72	2.51	0.88	154	28	11
30	56.84	2.82	33.25	2.48	0.87	153	38	12
Mean	56.07	2.82	33.19	2.50	0.89	150	31	11

APPENDIX F

SUBJECT 2

12 HR Fasted Run AMB. TEMP. - 24 C HUMIDITY (%) - 29
WEIGHT - 85.2 KG BARO. PRES. - 753 MM HG
RESTING HR - 64 RESTING BP - 124/76
TREADMILL SPEED - 5.0 mph % max VO_2 - 59
CALORIC EXPENDITURE (Kcal/30 min) - 368.27

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	51.67	2.48	29.10	2.29	0.92	155	26	11
10	53.93	2.53	29.69	2.36	0.93	157	30	12
15	53.04	2.48	29.10	2.29	0.92	159	29	12
20	53.42	2.42	28.52	2.26	0.93	165	31	12
25	51.87	2.48	29.10	2.21	0.89	159	31	12
30	54.62	2.54	29.81	2.30	0.90	164	34	12
Mean	53.09	2.49	29.22	2.29	0.92	160	30	12

APPENDIX F (continued)

SUBJECT 2

3 HR Fasted Run (RE) AMB. TEMP. - 24 C HUMIDITY (%) - 34
WEIGHT - 85.7 KG BARO. PRES. - 750 MM HG
RESTING HR - 60 RESTING BP - 130/98
TREADMILL SPEED - 5.0 mph % max VO_2 - 64.0
CALORIC EXPENDITURE (Kcal/30 min) - 400.27

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	50.01	2.37	27.77	2.29	0.96	154	24	10
10	57.01	2.75	32.08	2.58	0.93	164	28	12
15	58.45	2.67	31.27	2.54	0.95	169	27	12
20	61.56	2.82	32.90	2.66	0.94	171	32	12
25	58.28	2.69	31.38	2.50	0.93	173	33	12
30	63.12	2.84	33.25	2.67	0.93	180	35	13
Mean	58.07	2.69	31.44	2.54	0.94	169	30	12

APPENDIX G

SUBJECT 3

12 HR Fasted Run AMB. TEMP. - 24 C HUMIDITY (%) - 36
WEIGHT - 80.7 KG BARO. PRES. - 750 MM HG
RESTING HR - 68 RESTING BP - 126/88
TREADMILL SPEED - 5.0 mph % max VO_2 - 53
CALORIC EXPENDITURE (Kcal/30 min) - 326.70

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	42.98	2.08	25.89	1.81	0.86	131	23	7
10	46.25	2.20	27.38	1.91	0.87	131	27	9
15	48.65	2.28	28.25	1.97	0.86	131	32	10
20	48.29	2.30	28.62	1.99	0.86	134	28	11
25	50.31	2.36	29.24	2.01	0.85	127	30	12
30	48.45	2.25	27.88	1.93	0.85	133	27	12
Mean	47.49	2.25	27.88	1.94	0.86	131	28	10

APPENDIX G (continued)

SUBJECT 3

3 HR Fasted Run (DC) AMB. TEMP. - 22 C HUMIDITY (%) - 30
WEIGHT - 80.4 KG BARO. PRES. - 753 MM HG
RESTING HR - 64 RESTING BP - 128/82
TREADMILL SPEED - 5.0 mph % max VO_2 - 49
CALORIC EXPENDITURE (Kcal/30 min) - 303.44

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	45.34	2.11	26.24	1.91	0.91	127	30	7
10	45.01	2.03	25.24	1.85	0.91	125	30	8
15	46.43	2.04	25.37	1.87	0.92	126	31	8
20	46.14	2.01	25.12	1.87	0.92	131	33	8
25	47.31	1.99	24.75	1.85	0.93	127	36	8
30	49.42	2.13	26.61	1.97	0.91	133	36	8
Mean	46.61	2.05	25.56	1.89	0.92	128	33	8

APPENDIX H

SUBJECT 4

12 HR Fasted Run AMB. TEMP. - 22 C HUMIDITY (%) - 29
WEIGHT - 56.5 KG BARO. PRES. - 753 MM HG
RESTING HR - 64 RESTING BP - 124/84
TREADMILL SPEED - 7.0 mph % max VO_2 - 61
CALORIC EXPENDITURE (Kcal/30 min) - 339.07

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	37.26	2.44	43.18	2.00	0.82	145	30	9
10	38.67	2.29	40.53	2.01	0.88	N/A	25	9
15	42.87	2.28	40.35	2.00	0.87	N/A	30	10
20	40.70	2.21	39.29	1.93	0.87	N/A	29	10
25	41.54	2.50	44.42	2.08	0.83	N/A	30	11
30	39.23	2.34	41.59	1.95	0.83	N/A	28	11
Mean	40.05	2.34	41.56	2.00	0.85	N/A	29	10

APPENDIX H (continued)

SUBJECT 4

3 HR Fasted Run (TD) AMB. TEMP. - 24 C HUMIDITY (%) - 36
WEIGHT - 56.8 KG BARO. PRES. - 750 MM HG
RESTING HR - 71 RESTING BP - 118/88
TREADMILL SPEED - 7.0 mph % max VO_2 - 60
CALORIC EXPENDITURE (Kcal/30 min) - 341.22

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	40.79	2.42	42.78	2.16	0.89	133	29	9
10	40.04	2.37	41.72	2.08	0.88	146	27	10
15	35.95	2.23	39.26	1.91	0.85	146	29	11
20	40.06	2.37	41.72	2.08	0.87	150	26	11
25	38.59	2.41	42.60	2.07	0.85	147	26	11
30	32.70	2.29	40.49	1.83	0.80	146	25	11
Mean	38.02	2.35	41.43	2.02	0.86	145	27	11

APPENDIX I

SUBJECT 5

12 HR Fasted Run AMB. TEMP. - 24 C HUMIDITY (%) - 31
WEIGHT - 86.6 KG BARO. PRES. - 742 MM HG
RESTING HR - 56 RESTING BP - 118/76
TREADMILL SPEED - 5.5 mph % max VO_2 - 61
CALORIC EXPENDITURE (Kcal/30 min) - 416.01

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	56.42	2.91	33.60	2.67	0.92	143	29	9
10	56.84	2.79	32.21	2.57	0.92	146	32	9
15	57.34	2.82	32.56	2.59	0.92	146	30	10
20	52.37	2.86	33.02	2.53	0.88	144	23	10
25	55.89	2.88	33.37	2.58	0.89	149	30	10
30	52.39	2.69	31.06	2.41	0.89	147	27	10
Mean	55.21	2.83	32.64	2.56	0.90	146	29	10

APPENDIX I (continued)

SUBJECT 5

3 HR Fasted Run (TM) AMB. TEMP. - 24 C HUMIDITY (%) - 35
WEIGHT - 86.0 KG BARO. PRES. - 742 MM HG
RESTING HR - 64 RESTING BP - 114/78
TREADMILL SPEED - 5.5 mph % max VO_2 - 62
CALORIC EXPENDITURE (Kcal/30 min) - 417.08

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	53.01	2.79	32.44	2.53	0.90	132	29	10
10	53.12	2.74	31.86	2.53	0.92	137	25	10
15	56.29	2.79	32.44	2.62	0.93	142	31	10
20	57.42	2.88	33.60	2.67	0.92	143	34	10
25	56.93	2.84	33.13	2.61	0.91	144	34	10
30	57.59	2.88	33.60	2.62	0.91	148	33	10
Mean	55.73	2.82	32.85	2.60	0.92	141	27	10

APPENDIX J

SUBJECT 6

12 HR Fasted Run AMB. TEMP. - 24 C HUMIDITY (%) - 35
WEIGHT - 67.8 KG BARO. PRES. - 742 MM HG
RESTING HR - 56 RESTING BP - 136/68
TREADMILL SPEED - 6.5 mph % max VO_2 - 54
CALORIC EXPENDITURE (Kcal/30 min) - 341.55

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	41.34	2.20	32.59	2.04	0.92	120	23	8
10	45.20	2.41	35.54	2.24	0.92	125	23	10
15	45.20	2.19	32.30	2.11	0.96	130	30	11
20	44.70	2.28	33.62	2.12	0.93	127	26	12
25	45.56	2.33	34.36	2.16	0.92	129	28	12
30	49.45	2.36	34.80	2.23	0.94	129	33	13
Mean	45.24	2.30	33.87	2.15	0.93	127	27	11

APPENDIX J (continued)

SUBJECT 6

3 HR Fasted Run (WB) AMB. TEMP. - 24 C HUMIDITY (%) - 39
WEIGHT - 68.0 KG BARO. PRES. - 742 MM HG
RESTING HR - 50 RESTING BP - 140/86
TREADMILL SPEED - 6.5 mph % max VO_2 - 55
CALORIC EXPENDITURE (Kcal/30 min) - 349.04

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	50.68	2.41	35.58	2.28	0.94	118	26	8
10	50.81	2.32	34.11	2.23	0.95	122	26	8
15	48.12	2.33	34.26	2.13	0.91	122	30	9
20	48.56	2.37	34.85	2.17	0.91	124	29	10
25	48.59	2.33	34.26	2.12	0.91	124	32	11
30	48.75	2.37	35.00	2.16	0.90	126	31	11
Mean	49.25	2.36	34.68	2.18	0.92	123	29	10

APPENDIX K

SUBJECT 7

12 HR Fasted Run AMB. TEMP. - 24 C HUMIDITY (%) - 38
WEIGHT - 65.7 KG BARO. PRES. - 744 MM HG
RESTING HR - 61 RESTING BP - 118/72
TREADMILL SPEED - 5.0 mph % max VO_2 - 57
CALORIC EXPENDITURE (Kcal/30 min) - 259.37

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	39.29	1.81	27.54	1.60	0.88	137	35	8
10	38.64	1.79	27.24	1.56	0.86	137	36	9
15	38.56	1.72	26.17	1.49	0.86	134	38	10
20	38.06	1.79	27.24	1.52	0.84	137	37	10
25	39.34	1.81	27.54	1.52	0.84	134	31	10
30	39.70	1.83	27.85	1.54	0.83	138	30	11
Mean	38.90	1.79	27.26	1.54	0.85	136	35	10

APPENDIX K (continued)

SUBJECT 7

3 HR Fasted Run (CB) AMB. TEMP. - 23 C HUMIDITY (%) - 40
WEIGHT - 64.3 KG BARO. PRES. - 736 MM HG
RESTING HR - 62 RESTING BP - 118/80
TREADMILL SPEED - 5.0 mph % max VO_2 - 58
CALORIC EXPENDITURE (Kcal/30 min) - 264.74

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	44.84	1.87	29.08	1.79	0.96	139	40	9
10	43.23	1.89	29.39	1.74	0.91	140	40	10
15	42.87	1.77	27.52	1.64	0.92	144	44	10
20	42.45	1.77	27.68	1.64	0.92	139	42	11
25	40.81	1.75	27.37	1.62	0.91	139	40	11
30	39.29	1.70	26.59	1.54	0.90	140	40	12
Mean	42.25	1.79	27.94	1.66	0.92	140	41	11

APPENDIX L

SUBJECT 8

12 HR Fasted Run AMB. TEMP. - 22 C HUMIDITY (%) - 40
WEIGHT - 51.5 KG BARO. PRES. - 736 MM HG
RESTING HR - 72 RESTING BP - 112/74
TREADMILL SPEED - 5.5 mph % max VO_2 - 60
CALORIC EXPENDITURE (Kcal/30 min) - 245.31

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	34.20	1.70	33.00	1.49	0.87	146	32	10
10	32.23	1.66	32.23	1.41	0.84	150	31	10
15	32.15	1.74	33.78	1.45	0.83	148	32	10
20	33.50	1.72	33.39	1.47	0.86	153	33	10
25	33.12	1.74	33.78	1.47	0.84	157	24	10
30	30.96	1.66	32.42	1.37	0.82	154	31	10
Mean	32.69	1.70	33.10	1.44	0.84	151	31	10

APPENDIX L (continued)

SUBJECT 8

3 HR Fasted Run (JM) AMB. TEMP. - 24 C HUMIDITY (%) - 38
WEIGHT - 52.1 KG BARO. PRES. - 744 MM HG
RESTING HR - 62 RESTING BP - 106/64
TREADMILL SPEED - 5.5 mph % max VO_2 - 57
CALORIC EXPENDITURE (Kcal/30 min) - 243.54

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	39.68	1.70	32.62	1.62	0.95	137	34	10
10	37.73	1.66	32.05	1.54	0.92	137	33	11
15	35.34	1.62	31.09	1.45	0.90	140	33	11
20	36.54	1.60	30.71	1.45	0.91	143	34	11
25	36.01	1.64	31.47	1.47	0.89	144	25	11
30	36.56	1.68	32.43	1.50	0.88	148	33	11
Mean	36.98	1.65	31.73	1.51	0.91	142	32	11

APPENDIX M

SUBJECT 9

12 HR Fasted Run AMB. TEMP. - 24 C HUMIDITY (%) - 36
WEIGHT - 62.6 KG BARO. PRES. - 750 MM HG
RESTING HR - 61 RESTING BP - 102/72
TREADMILL SPEED - 5.0 mph % max VO_2 - 58
CALORIC EXPENDITURE (Kcal/30 min) - 243.49

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	37.67	1.68	26.83	1.49	0.88	124	29	9
10	37.90	1.64	26.35	1.45	0.87	124	35	9
15	38.06	1.60	25.55	1.41	0.88	134	41	9
20	38.34	1.62	26.03	1.41	0.86	134	30	9
25	43.29	1.77	28.43	1.54	0.86	136	42	10
30	40.29	1.70	27.31	1.47	0.86	139	42	10
Mean	39.26	1.67	26.75	1.46	0.87	132	37	9

APPENDIX M (continued)

SUBJECT 9

3 HR Fasted Run (MM) AMB. TEMP. - 22 C HUMIDITY (%) - 29
WEIGHT - 62.3 KG BARO. PRES. - 753 MM HG
RESTING HR - 64 RESTING BP - 110/70
TREADMILL SPEED - 5.0 mph % max VO_2 - 57
CALORIC EXPENDITURE (Kcal/30 min) - 237.65

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	40.84	1.62	26.16	1.50	0.91	121	28	8
10	38.53	1.56	25.20	1.41	0.89	124	34	9
15	42.20	1.64	26.48	1.47	0.89	130	23	10
20	42.37	1.62	26.16	1.45	0.89	125	40	10
25	42.17	1.66	26.80	1.47	0.88	129	33	11
30	40.54	1.62	26.00	1.43	0.88	137	37	11
Mean	41.11	1.62	26.13	1.46	0.89	128	33	10

APPENDIX N

SUBJECT 10

12 HR Fasted Run — AMB. TEMP. - 24 C HUMIDITY (%) - 31
WEIGHT - 51.6 KG — BARO. PRES. - 742 MM HG
RESTING HR - 66 — RESTING BP - 114/72
TREADMILL SPEED - 6.0 mph — % max VO_2 - 61
CALORIC EXPENDITURE (Kcal/30 min) - 263.63

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	38.06	1.87	36.43	1.52	0.81	141	33	10
15	37.15	1.87	36.43	1.50	0.80	146	23	11
20	35.31	1.79	34.88	1.43	0.79	148	31	11
25	35.51	1.87	36.24	1.47	0.79	149	30	11
30	37.26	1.83	35.65	1.45	0.79	149	35	11
Mean	36.66	1.85	35.93	1.47	0.80	146	30	11

APPENDIX N (continued)

SUBJECT 10

3 HR Fasted Run (HR) AMB. TEMP. - 24 C HUMIDITY (%) - 31
WEIGHT - 51.0 KG BARO. PRES. - 742 MM HG
RESTING HR - 56 RESTING BP - 104/82
TREADMILL SPEED - 6.0 mph % max VO_2 - 56
CALORIC EXPENDITURE (Kcal/30 min) - 245.39

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	34.62	1.70	33.33	1.47	0.86	132	28	9
10	35.18	1.62	31.76	1.43	0.88	132	32	9
15	36.12	1.66	32.74	1.47	0.87	131	35	10
20	34.65	1.70	33.52	1.47	0.86	134	32	10
25	35.18	1.75	34.50	1.50	0.84	135	32	10
30	34.98	1.68	33.13	1.43	0.85	138	34	10
Mean	35.12	1.69	33.16	1.46	0.86	134	32	10

APPENDIX O

SUBJECT 11

12 HR Fasted Run AMB. TEMP. - 24 C HUMIDITY (%) - 36
WEIGHT - 73.4 KG BARO. PRES. - 742 MM HG
RESTING HR - 55 RESTING BP - 114/76
TREADMILL SPEED - 5.5 mph % max VO_2 - 68
CALORIC EXPENDITURE (Kcal/30 min) - 393.01

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	65.21	2.79	38.01	2.50	0.89	134	31	9
10	62.21	2.63	35.96	2.37	0.90	131	37	9
15	61.62	2.62	35.83	2.37	0.89	138	36	9
20	64.40	2.76	37.73	2.46	0.89	155	24	9
25	61.15	2.67	36.51	2.32	0.86	151	31	9
30	60.12	2.65	36.10	2.28	0.86	157	37	9
Mean	62.44	2.69	36.69	2.38	0.88	144	33	9

APPENDIX O (continued)

SUBJECT 11

3 HR Fasted Run (MP) AMB. TEMP. - 24 C HUMIDITY (%) - 31
WEIGHT - 72.4 KG BARO. PRES. - 742 MM HG
RESTING HR - 54 RESTING BP - 114/66
TREADMILL SPEED - 5.5 mph % max VO_2 - 67
CALORIC EXPENDITURE (Kcal/30 min) - 379.86

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	61.93	2.70	37.29	2.44	0.90	127	38	9
10	59.40	2.59	35.91	2.30	0.88	123	39	9
15	56.48	2.54	35.08	2.25	0.89	126	37	9
20	59.29	2.70	37.29	2.37	0.88	123	33	9
25	55.73	2.55	35.35	2.23	0.87	126	39	9
30	55.09	2.54	35.08	2.20	0.86	129	39	9
Mean	57.99	2.60	36.00	2.30	0.88	126	38	9

APPENDIX P

SUBJECT 12

12 HR Fasted Run AMB. TEMP. - 24 C HUMIDITY (%) - 35
WEIGHT - 47.9 KG BARO. PRES. - 742 MM HG
RESTING HR - 51 RESTING BP - 122/60
TREADMILL SPEED - 5.0 mph % max VO_2 - 60
CALORIC EXPENDITURE (Kcal/30 min) - 219.64

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	35.68	1.50	31.31	1.41	0.93	132	34	11
10	33.37	1.49	31.10	1.33	0.88	136	31	11
15	34.09	1.47	30.89	1.31	0.88	138	31	12
20	33.68	1.50	31.31	1.31	0.87	137	28	12
25	33.98	1.50	31.52	1.29	0.85	141	31	12
30	33.59	1.56	32.56	1.31	0.84	141	31	13
Mean	34.07	1.50	31.45	1.33	0.88	138	31	12

APPENDIX P (continued)

SUBJECT 12

3 HR Fasted Run (LB) AMB. TEMP. - 24 C HUMIDITY (%) - 39
WEIGHT - 48.2 KG BARO. PRES. - 742 MM HG
RESTING HR - 48 RESTING BP - 100/62
TREADMILL SPEED - 5.0 mph % max VO_2 - 55
CALORIC EXPENDITURE (Kcal/30 min) - 205.80

Time min	V_E L/min	VO_2 L/min	VO_2 ml/kg	VCO_2 L/min	R	HR BPM	RR BPM	RPE
5	30.25	1.37	28.42	1.27	0.92	110	30	8
10	30.82	1.41	29.25	1.29	0.91	119	32	8
15	30.39	1.41	29.25	1.27	0.90	121	31	9
20	30.52	1.43	29.66	1.27	0.89	124	31	10
25	29.85	1.37	28.63	1.22	0.88	125	32	11
30	31.09	1.39	28.83	1.25	0.89	129	33	11
Mean	30.49	1.40	29.01	1.26	0.90	121	32	10

REFERENCES

Abraham, S. and C. L. Johnson
1980 "Prevalence of severe obesity in adults in the United States." American Journal of Clinical Nutrition 33:364.

American College of Sports Medicine
1980 Guidelines for Graded Exercise Testing and Exercise Prescription. Philadelphia: Lea & Febiger.

American College of Sports Medicine
1986 Guidelines for Graded Exercise Testing and Exercise Prescription. Philadelphia: Lea & Febiger.

American College of Sports Medicine
1983 Position Stands and Opinion Statements (1975-1984). Indianapolis: American College of Sports Medicine.

Cohen, Louis and Michael Holliday
1979 Statistics for Education and Physical Education. London: Harper & Row.

Costill, D. L.
1970 "Metabolic responses during distance running." Journal of Applied Physiology 28:251-255.

Craddock, D.
1978 Obesity and Its Management. New York: Churchill Livingston.

Fredrickson, D.S. and R.S. Gordon, Jr.
1958 "Transport of fatty acids." Physiological Reviews 38:585.

Fritz, I. B.
1961 "Factors influencing the rates of long-chain fatty acid oxidation and synthesis in mammalian systems." Physiological Reviews 17:32-41.

Gwinup, G.
1975 "Effect of exercise alone on the weight of obese women." Archives of Internal Medicine 135:676-680.

Havel, R. J., A. Naimark and C. F. Borchgrevink
1963 "Turnover rate and oxidation of free fatty acids of blood plasma in man during exercise: Studies during continuous infusion of palmitate 1-C^{14}." Journal of Clinical Investigations 42 7:1054.

Hermansen, L. and I. Stensvold
1972 "Production and removal of lactate during exercise in man." Acta Physiologica Scandinavica 86:191-201.

Hockey, Robert
1985 Physical Fitness: The Pathway to Healthful Living. St. Louis: Times Mirror/Mosby College Publishing.

Issekutz, B., Jr., H. I. Miller, and K. Rodahl
1966 "Lipid and carbohydrate metabolism during exercise." Federation Proceedings 25:1415-1426.

Jackson, A. J. and M. L. Pollock
1985 "Practical Assessment of Body Composition." The Physician and Sportsmedicine 13 5:76-90.

Konopka, B. J. and E. M. Haymes
1985 "Protein utilization during submaximal exercise in trained men and women." Medicine and Science in Sports and Exercise 17 2:232.

Leon, A. S., et al
1979 "Effects of a vigorous walking program on body composition and carbohydrate and lipid metabolism of obese young men." American Journal of Clinical Nutrition 32:1776-1787.

McArdle, W. D., F. I. Katch, and V. L. Katch
1981 Exercise Physiology: Energy, Nutrition and Human Performance. Philadelphia: Lea & Febiger.

Osness, W. H., et al
1968 "The metabolic role of lipids in the production of energy during exercise." Physiological Aspects of Sports and Physical Fitness. The Athletic Institute 91-99.

Nagle, F., et al
1970 "Lactic acid accumulation during running at submaximal aerobic demands." Medicine and Science in Sports 2:182-186.

Paul, P. and B. Issekutz, Jr.
1967 "Role of extramuscular energy sources in the metabolism of the exercising dog." Journal of Applied Physiology 22:615-622.

Pollock, M.L., T. K. Cureton, and L. Greninger
1969 "Effects of frequency of training on work capacity, cardiovascular function and body composition of adult men." Medicine and Science in Sports 1:70-74.

Pollock, M. L.
1973 The Quantification of Endurance Training Programs. Exercise and Sports Science Reviews, J. Wilmore (Ed.) New York: Academic Press.

Powers, Scotty K., William Riley, and Edward T. Howley
1980 "Comparison of fat metabolism between trained men and women during prolonged aerobic work." Research Quarterly for Exercise and Sport 51 2:427-431.

Sinning, Wayne E.
1975 Experiments and Demonstrations in Exercise Physiology. Philadelphia: W. B. Saunders Company.

Siri, W. E.
1961 "Body composition from fluid spaces and density: analysis of methods in techniques for measuring body composition." Washington, D. C.: National Academy of Science, National Research Council 223-244.

Storlie, Jean and Henry A. Jordan
1984 Evaluation and Treatment of Obesity. New York: Spectrum Publications, Inc.

Weltman, A., S. Matter, and B. A. Stamford
1980 "Caloric restriction and/or mild exercise: effects on serum lipids and body composition." American Journal of Clinical Nutrition 33:1002-1009.

Wilcox, A. R., R. Harford, and D. J. Wedel
1985 "The effect of fasting on fat utilization during running." Medicine and Science in Sports and Exercise 17 2:258.

Wilmore, J. H., et al
1970 "Body composition changes with a 10 week jogging program." Medicine and Science in Sports 2:113-117.

Zuti, W. B. and L. A. Golding
1976 "Comparing diet and exercise as weight reduction tools." The Physician and Sportsmedicine 4 1:49-53.